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Use of Renewable Energy in Contingency Operations

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The strategic importance of having an unimpeded source of energy is becoming ever more crucial. The significance of energy and the need for greater energy responsibility by the United States have been identified in several State of the Union Addresses. President Bush?s 2006 State of the Union Address identified ?America is addicted to oil? encouraging Federal agencies to lead the way in developing more reliable alternative energy programs. In July 2006, MG Richard Zilmer, Chief of Multi-National Forces West, identified a crucial need for ?a self-sustainable energy solution? available for use by U.S. forces in Iraq. Use of renewable energy system is one way to help decrease dependency on fossil fuels and offer Warfighters alternative sources of energy to accomplish their mission. This paper will explore the institutional impediments that prevent the Army from increasing its use of renewable energy systems in Contingency Operations and make recommendations to overcome those barriers in order to enhance use of renewable energy thereby becoming less dependent of foreign oil.

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The images on the cover depict some of the renewable energy systems available for use in Contingency Operations.

Top Left
The sun as an unlimited source of solar energy.

Top Center
Photovoltaic thin film sheet draped over the top of a field tent. Photo by Air Force Research Laboratory.

Lower Left
An Army trailer with Photovoltaic thin film sheets and wind turbine configuration. Photo by Rapid Equipping Force.

Lower Center
Thin film Photovoltaic panels for recharging batteries. Photo by U.S. Army Natick Soldier Center.

Upper Right.
Wind turbine.

Right Center
Solar/Wind Light. Photo by Sustainable Transportation Division, Fort Bragg, North Carolina.

Lower Right
Mini hydro power unit.

UNITED STATES ARMY WAR COLLEGE
CIVILIAN RESEARCH PROJECT

USE OF RENEWABLE ENERGY IN CONTINGENCY OPERATIONS

by

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ABSTRACT

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ACRONYMS

AEPI	……	Army Environmental Policy Institute
AFRL	……	Air Force Research Laboratory
CINC	……	Commander in Chief
CONOPS	……	Contingency Operations
CONUS	……....	Continental United States
COTS	……	Commercial Off the Shelf
DEPPM	……	Defense Energy Program Policy Memorandum
DNBI	……	Disease and Non-Battle Injury
DoD	……	Department of Defense
HMMWV	……	High Mobility Multi-purpose Wheeled Vehicle
IED	……	Improvised Explosive Device
KW	……	Kilowatt
METL	……	Mission Essential Task List
MISER	……	Mobile Integrated Sustainable Energy Recovery
MRAP	……	Mine Resistant Ambush Protected
MWR	……	Morale, Welfare, and Recreation
RES	……	Renewable Energy System
TOE	……	Table of Organization and Equipment

Use of Renewable Energy in Contingency Operations

Background

In his 2006 State of the Union address, President George W. Bush identified that "Keeping America competitive requires affordable energy. And here we have a serious problem. America is addicted to oil, which is often imported from unstable parts of the world." President Bush went on to identify breakthroughs and new technologies which could help reach "another great goal: to replace more than 75 percent of our oil imports from the Middle East by 2025" moving away from a petroleum based economy and becoming less dependent on oil[1]. Energy concerns were again addressed in the 2007 State of the Union Address with similarities to the previous address.

The price of oil addiction can come at a high cost – the cost of vulnerability. The United States becomes vulnerable politically, economically, and strategically[2] as the oil suppliers to the United States, and therefore the United States Army, either become adversaries or use oil as leverage against the United States. A relatively small or slightly moderate interruption in the supply of oil or natural gas will have significant economic ramifications for the United States[3], potentially generating important strategic considerations.

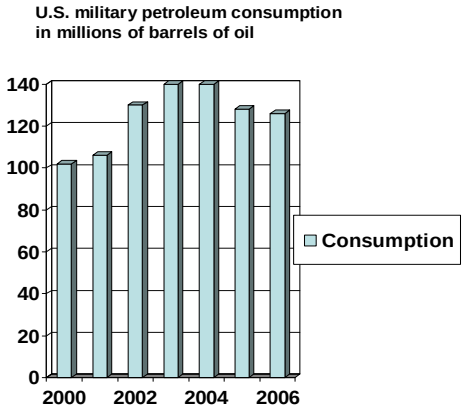
In July 2006, Venezuelan President Hugo Chavez stated that if the United States were to invade Iran, the United States would pay [Venezuela] $200 per barrel of oil. President Chavez also stated "not one drop of Venezuelan oil would reach the [United States] in the event of military aggression" against him[4]. Should this action occur with the United States importing approximately 13% of its oil from Venezuela[5], there would most certainly be an impact on the price for oil. This in turn could significantly influence

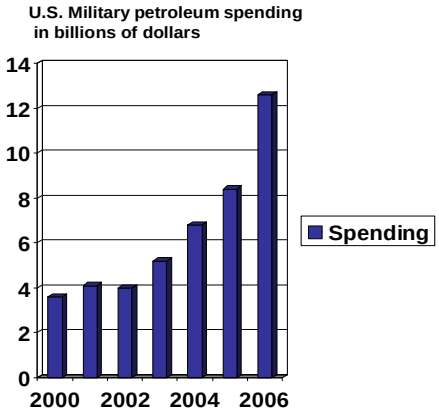
strategic considerations for the United States and possibly impact military operations. Having withstood gasoline at $4.00 per gallon [cost per barrel of oil about $70-75] shortly after Hurricane Katrina[6] based on a modest interruption in oil imports (approximately 25% of U.S. Crude oil production), oil for $200 per barrel would certainly have a significant impact on the United States.

Even with use of the Strategic Petroleum Reserve[7] to stabilize costs, at an extremely elevated price in the cost for oil, and without predictable relief in the supply of oil in sight, one would expect immeasurable economic consequences not only for the United States but potentially for the United States Army as well. As the cost for fuel increases, it can have direct implications for the military as over 50% of the fuel used by the Army is consumed by combat support units. Before oil was $70 per barrel, the Army spent approximately $200 million annually on fuel, yet paid over $3 billion yearly on 60,000 National Guard and Reservists to transport it.

Table 1

U.S. military petroleum consumption and spending





Source: U.S. Defense Energy Support Center

Note: Figures for fiscal years ending Sept. 30

In 2005, the United States military used approximately 128 million barrels of fuel at a cost of about $8 billion as seen in Table 1[8]. This is compared to use of 145 million barrels of fuel in 2004 at a cost of $7 billion. Based on the 2005 128 million barrel usage, it is clear that oil over $70 per barrel could easily cost the United States military well over $10 billion annually excluding transportation cost[9].

109th Congress

The 109th Congress acknowledged a broad range of renewable energy technologies and resources including biomass, solar, and wind is currently available for use. More than 290 energy efficiency and renewable energy bills were introduced during the 109th Congress with fewer than five percent passed into law with fewer yet impacting the Army. During the second session of the 109th Congress, H.R. 4897 the Renewable Energy Systems and Energy Efficiency Improvements Program of the Department of Agriculture through fiscal year 2011 was cited as the "Renewable Energy Systems and Energy Efficiency Improvements Program Act of 2006." Congress reported the following findings[10]:

> (1) Having an affordable, reliable, and plentiful energy supply is critical to the United States economy.
>
> (2) Current and future risks to United States energy security are increasing at the same time that domestic and global energy demands are growing exponentially.
>
> (3) The greatest strength of United States agriculture has always been the entrepreneurial strength of its farmers and ranchers, and this entrepreneurial strength can be harnessed to increase United States energy security.
>
> (4) The development of a broad range of renewable energy sources, including wind power, biomass, ethanol, biodiesel, and solar, offers the potential for farmers and ranchers to develop additional sources of income, for rural

businesses and communities to prosper, and for the United States to lessen its dependence on imported oil. ..

(8) During its first two years in operation, the Renewable Energy Systems and Energy Efficiency Improvements Program leveraged approximately $44 million in grants into more than $300 million in clean energy projects, including 250 megawatts of wind power, 67 anaerobic digesters, 8 biofuels processing facilities, 85 energy efficiency projects, and a range of other proven energy efficiency technologies.

(9) The Renewable Energy Systems and Energy Efficiency Improvements Program [receives] strong bipartisan support in Congress and among a broad range of farm, environmental, and sustainable energy organizations.

(10) Growing interest in the Renewable Energy Systems and Energy Efficiency Improvements Program is evidenced by the 63 percent increase in the number of applications from 2004 to 2005 for assistance under the program, but the shortfall in funding allowed only 40 percent of applications to be funded in 2005 (versus 70 percent in 2004).

(11) Section 1301 of the Deficit Reduction Act of 2005 (Public Law 109-171; 120 Stat. 4) reduces fiscal year 2007 funding for the Renewable Energy Systems and Energy Efficiency Improvements Program from $23 million to $3 million.

While these findings substantiate and support the need for continued development and use of renewable energy systems, significant reduction in funding from the Deficit Reduction Act of 2005 will make this very challenging. Decreasing funding from $23 million to only $3 million for Renewable Energy Systems and Energy Efficiency Improvements Program is troubling. Proper funding for energy technology and improvements in renewable energy systems is in the military's best interest and the military should more aggressively pursue enhancing its use of renewable energy. The military needs to take the lead to incorporate renewable energy systems and technology as an integral part of combat system support.

Although the importance of using alternative energy systems is clearly articulated by President Bush and communicated through the findings of the second session of the 109th Congress, funding for renewable energy technology use steadily declines and the United States continues to use imported oil at an ever increasing rate. This is seen in the

chart on Table 2 where the top five countries exporting oil to the United States accounted for 64% of oil imports and the top 10 sources accounted for 84% of United States' crude oil imports[11]. Quite simply, the United States' oil addiction continues to grow.

Table 2
Crude Oil Imports (Top Ten Countries)
Thousand Barrels per day in the United States*

Country	Sep 2006	Aug 2006	YTD 2006	Sep 2005
Canada	1,747	1,850	1,755	1,670
Saudi Arabia	1,546	1,477	1,424	1,286
Mexico	1,441	1,652	1,636	1,249
Venezuela	1,129	1,151	1,157	1,073
Nigeria	917	898	1,055	959
Iraq	655	620	572	443
Angola	648	525	503	451
Algeria	438	506	350	218
Ecuador	319	285	273	191
Kuwait	227	136	166	235

** Taken from Energy Information Administration website 20 November 2006[12].*

Strategic Considerations

Having dependable, secure energy is a national security issue. The United States Army will always require energy as a key resource to accomplish its mission. Some may believe in an underlying false perception of the United States having an endless supply of energy no matter where we live, operate, or fight. This may be attributed to the continued growth in oil use. Yet, as national and international conflicts continue around the world and the United States becomes involved in these conflicts - whether peace keeping, conducting stability operations, nation building, or providing humanitarian aid[13] - the United States Army can expect to operate in austere environments with little host nation

infrastructure to support the mission and quite possibly little host nation governmental support or governmental involvement. In the 2006 State of the Union Address, the President identified other areas of the world that required freedom, justice, and peace naming Syria, Burma, and Zimbabwe[14]. If the United States were to become involved with efforts to provide the freedom, justice and peace identified in the address, the austere environments of these countries, limited host nation infrastructure, and projected remoteness of operations will have a definite and dramatic impact on operations, especially logistic support.

Given the United States imported approximately 2 millions barrels of oil daily from three African countries (Nigeria, Algeria, and Angola) in September 2006, as seen in Table 2, the strategic importance of Africa is clear. Furthermore, by September 2008[15] the Pentagon plans to stand up a regional command dedicated to the entire African continent in which Africa will fall under one command instead of its current organization of three regional commands (European Command, Central Command, and Pacific Command) reinforcing Africa's strategic importance[16]. Also of consideration are the ever increasing presence of Islamic extremists in Somalia and the spread of Islam in other African countries. It is unclear how this dynamic will or could impact oil exports from Africa to the United States.

If African based United States Embassies were again threatened or attacked as they were in 1998 by Al Qaeda, or relationships between African countries spoil due to pressure or unrest from various factions or governments in Africa[17], continued genocide, human rights violations, state sponsored terrorism, political concerns, or extreme alteration of economic or social situations from extreme famine, African oil imports to

the United States could be threatened. The same scenario can present in other regions of the world where oil is exported to the United States, including South America, potentially compromising the oil available for the United States to import.

The continued perceptions and thinking of "doing things like we have always done" pertaining to the endless supply and re-supply of fuel and energy is fatalistic thinking. The Chinese Philosopher Lao-tse stated:

> *In managing affairs there is no better advice than to be sparing.*
> *To be sparing is to forestall.*
> *To forestall is to be prepared and strengthened.*
> *To be prepared and strengthened is to be ever successful.*
> *To be ever successful is to have infinite capacity.*
>
> Chinese Philosopher Lao-tse, two and a half millennia ago.
> (*In Tao Te Ching 59)*[18]

Only when the United States is significantly less dependent on foreign oil can it explore the full extent of its capacity.

Implications for the Army

Commanders[19] must explore alternative means of energy that not only diminish the continued need for fossil based fuels but also energy that allows for maintaining current operational systems during high level conflict without degrading the mission. Viet-Nam, Somalia, Afghanistan, and Iraq have demonstrated that guerrilla warfare is an effective means of resisting a well equipped force. It is highly unlikely that future battles or battlefields will have huge armies squared off force on force as in WWI and WWII.

Future conflicts or engagements will most likely occur in impoverished countries with minimal or very limited infrastructure, making traditional military operations challenging. Asymmetrical, irregular warfare with engagements taking place in urban

areas, rural settings, or on inhospitable terrain will make maneuvering and re-supply extremely difficult. Commanders must examine all aspects of military operations, exploring potential renewable sources of power (photovoltaic, wind, hydro, and/or biomass) for base operations and power source(s) to run generators for maintenance of communications, health and welfare needs, and so forth.

Renewable energy systems offer viable, dependable sources of energy that can effectively augment, and in some cases replace, current fossil fuel generator systems. In austere settings with asymmetrical, irregular warfare, commanders must ask several questions. What is the strategic importance of having an unimpeded source of energy especially when operating in an austere environment? Where will this source of energy, come from? How will commanders ensure they will have enough energy during Contingency Operations (CONOPS)[20]? How will fuel get to them when roads are almost nonexistent or too dangerous to travel? How will commanders complete their mission when they cannot rely on their previously dependable or relied on sources of energy?

In July 2006, MG Zilmer, Chief of Multi National Forces West, sent a memo to the Pentagon identifying a crucial need for "a self-sustainable energy solution" to be available for use by U.S. forces in Iraq.[21] MG Zilmer went on to say: "A proposed alternate solution – one that reduces the number of convoys while providing an additional capability to outlying bases – is to augment our use of fossil fuels with renewable energy, such as photovoltaic solar panels and wind turbines, at our outlying bases… By reducing the need for [petroleum-based fuels] at our outlying bases, we can decrease the frequency of logistics convoys on the road, thereby reducing the danger to our Marines, soldiers, and sailors…If this need is not met, operating forces will remain unnecessarily exposed

to IED, RPG, and [small arms fire] theatres and will continue to accrue preventable Level III and IV serious and grave casualties resulting from motor vehicle accidents and …attacks," "continued casualty accumulation exhibits potential to jeopardize mission success.[22]" In October 2006, 53 US personnel died from improvised explosive devices (IED) and 49 U.S. personnel died from IEDs in November. By mid December 2006, 53 soldiers or 60% of all casualties resulted from roadside bombs[23] supporting the concern raised by MG Zilmer in July.

Army 2006 Posture Statement

The Army's 2006 Posture Statement addresses the need for maintaining a properly trained and equipped force with the ability to deploy anywhere in the world, executing a synchronized plan to meet the National Military Strategy, and achieving a new global posture.[24] In order to accomplish this, transformation is required throughout all levels of the United States Army and should include incorporation of renewable energy systems. With the uncertainty of future operational environments, Army leaders must be innovative, agile, versatile, and multi-skilled in order to accomplish the mission. Educational systems and training must evolve beyond their current state and include incorporating new technologies. Exploring and implementing use of renewable energy systems during times of change and uncertainty is becoming a necessity. Renewable energy systems can help ensure readiness of expeditionary operations with little forewarning, providing the integration of equipment necessary to meet the intent of DoD and the President.

Commanders must consider how to most effectively employ renewable energy systems thereby enhancing their operational ability, reducing unnecessary soldier exposure to enemy attack with fuel hauling convoys, cause significant logistical weight reduction from handling and hauling fuel, decreasing vulnerability to disruption of energy supply, and employing measures to maintain the strategic importance of energy security within their area of operation. Commanders should explore how to best employ renewable energy systems and how the enemy may counter their use. Asking how can our enemy overcome our use of renewable energy and taking actions against those options increases the Commander's operational ability and helps to ensure availability of necessary energy. Anticipating an increased demand of energy from a Host Nation system that is typically aged, and will most likely have difficulty meeting its own needs let alone the needs of the Army, should emphasize the importance of energy vulnerability reinforcing the need to secure a reliable source of energy for operational needs.

Defense Energy Program Policy Memorandum

On 14 January 1992, the Office of the Assistant Secretary of Defense released Defense Energy Program Policy Memorandum (DEPPM) 92-1. The Memorandum addressed Department of Defense Energy Security Policy and stated "It is the basic responsibility of Defense managers and commanders to know the vulnerability of their missions and facilities to energy disruptions and the risk of such disruptions, whether the energy source is internal or external to the command. Lastly, it is essential to take action to eliminate critical energy support vulnerabilities.[25]" The Memorandum goes on to identify "Defense managers and commanders will (1) conduct energy vulnerability

analyses and review for currency annually… and (3) develop and execute remedial action plans to remove unacceptable energy security risks.[26]" However, reviewing various DEPPM published over the past 15 years identified discussion of various issues such as Greening the Federal Government, construction contracts, conservation audits, energy rebates and the like, but do not address energy vulnerability. Use of renewable energy systems is one way to decrease the vulnerability of energy disruption and reduce associated risk from energy disruption as renewable energy systems do not require fossil fuel to operate.

Current Use of Renewable Energy Systems

While renewable energy systems are currently used by the Army, most renewable energy systems are located in garrison settings throughout CONUS[27] . Proportionally, few renewable energy systems are used in Table of Organization and Equipment (TOE) settings or with CONOPS. Both the 82nd Airborne and 3/504th Parachute Infantry Regiment [PIR] have experienced success[28] in using renewable energy systems to power communications systems while also maintaining their stealth posture. These renewable energy systems are now forward deployed. Efforts by the Soldier Center at Natick, Massachusetts are increasingly important for bringing photovoltaic systems to tactical settings ([Shelter systems panels, tent cover/shade] [Individual portable power: thin film wallet, thin film fold/roll-able]). Natick identifies advantages of photovoltaics as[29]:

1. -Reducing the soldier's load while supplying renewable power
2. -Improving sustainability - extend mission, go farther and [last] longer
3. -Reduce logistical supply tail - minimize vulnerability of fuel/energy lines

4. -User friendly - less labor, maintenance and training
5. -Less heat signature than generators
6. -No Acoustic Signature
7. -Clean Energy – no emissions, pollutants [no or low smoke signature, low detectability, supports the environment]
8. -Cost Reductions – fewer batteries, less fuel, decreased waste disposal, reduced logistics of resupply.

The current Warfighter has a high demand for energy to power new weapons systems and associated Warfighting equipment (radios, optical devices, etc.) which typically comes in the form of batteries. In Iraq, the normal mission is about 12-18 hours in duration, yet battery life is typically less than 8 hours. Soldiers may be required to change their system batteries 2-3 times during a given mission. A rifle platoon's five day mission can require 889 batteries totaling 160 pounds (33 pounds from AA batteries alone) at an estimated cost of $13,000 for batteries.[30] This clearly illustrates a need for renewable power options and, specifically, rechargeable batteries and battery recharging systems to augment present and future energy sources.

The Air Force Research Laboratory (AFRL), Tyndall Air Force Base, Florida has been developing base support system using photovoltaic technology. A solar energy study[31] identified that solar energy provides reliability and durability, energy availability, and reduction in utility demand. AFRL's work cites solar power generation can[32]:

1. -decrease the logistic footprint,
2. -reduce the weight and cost of military operations,
3. -reduce system vulnerability to enemy attack,

4. -and reduce the weight and size of military generators.

Work continues towards use of dye sensitized solar cells which will allow for bifacial configuration (two main surfaces), transparency property for windows, variation of color, compatibility with roll-to-roll processing, greater efficiency than traditional silicon cells, and less expensive systems.

SkyBuilt Power "plug and play", see appendix A, allows for a variety of configurations for power generating needs and power storage capabilities. SkyBuilt units are heavy steel containers that can deliver anywhere between 3.5 to 150 kilowatts (kw) of electricity. Use of commercial off the shelf (COTS) components and technology allows for mixing and matching component sets to suit the needs of the user[33]. The trailer system can provide solar energy from 24 panels with 170 watt capacity per panel, 900 watts or 5kw energy from a mounted wind turbine, or derive energy in the form of AC or DC power from a small bladder turbine dropped in moving water[34].

Biomass generators and Waste to Energy Converter systems such as Mobile Integrated Sustainable Energy Recovery (MISER) are viable options currently fielded as a military to military test in El Salvador and at Natick Soldier Center, respectively. These systems use carbon based products (wood, cardboard, kitchen scraps, cooking oils, etc.) as their source of fuel for energy production, providing fuel flexibility and grid quality power. Output energy can be as much as 150kw to provide power for heating tents, run electrical systems, heat water, power tents, etc., at little cost, thus reducing the use of fossil fuels and cost avoidance.

The Salvadoran Calvary Base outside of San Salvador, El Salvador has two Biomass generators to provide energy (Appendix B). Currently, the Biomass generators

utilizes coconut husks, bamboo, and wood as fuel sources to produce energy to power electrical needs of the 150-500 man force. Power generation to the Calvary Base occurs at an annual cost of approximately $30,000 and other possible fuel sources are being considered.

Efficiency of Renewable Energy Systems

Renewable energy systems have varying degrees of efficiency. Photovoltaic efficiencies are influenced by the type of material used, configuration, and weather conditions. Efficiency of photovoltaic systems range typically from 12-20% with systems designed to enhance or boost photovoltaic system outputs. As efficiency varies, so too does the life expectancy of photovoltaic systems. Some systems have a 20-30 year identified life expectancy with degradation of only 5-10 percent in the functioning of the photovoltaic system. Wind turbines are reported to have a three to five year life expectancy and beyond with the need to only monitor the turbine system on a three month cycle. Dave Muchow, owner and Chief Executive Officer of SkyBuilt Power reported that his system "can cut cost by 75% while improving reliability, saving manpower and spare parts, reducing or eliminating fuel costs, handling, and logistics, and providing a low heat signature[35]" yet operating more quiet than traditional generators.

As these systems are not dependent on fossil fuel to operate, the actual savings through system efficiency is unlimited. Soldier safety is increased through reducing the logistics signature and funds for purchasing of fossil fuel are greatly diminished and can be diverted for other purposes as they are no longer required for energy generation. Renewable energy systems can easily provide energy for communication systems,

medical equipment, light tents, heat and air conditioning, hot water, power dining facilities, and morale, welfare and recreation (MWR) items at a cost unmatched by traditional fossil fuel energy generators.

Advantages of Renewable Energy Systems

Use of renewable energy systems during CONOPS has multiple and varied advantages for Commanders. Advantages include[36]: reducing the logistic footprint by decreasing the fuel requirement by as much as 20-30%, augmentation of power by up to 30%, a decrease in maintenance needs, and overall reduction in cost from fuel savings both in decreased fuel use and cost of hauling fuel. Further benefits occur in reduction in the size and weight of noisy, fuel consuming power units, reduction of weight requirements for military operations through use of lighter equipment, and increased security through reduction of thermal image, improved stealth with reduced noise, and greater control of intelligence through decreased waste. By decreasing waste there is a significant restriction on potential enemy information gathering efforts through removal of a readily accessible source of material found in landfills. Biomass generators and MISER waste to energy systems give a reduction of water requirements of up to 50-80% and significantly decrease or eliminate transportation needs for waste disposal.

Commanders have enhanced maneuverability, greater flexibility, and increased agility when using lighter renewable energy systems. Force protection and physical security are greatly improved by limiting soldier exposure to attack through significantly decreasing the number of convoys with less demand for fossil fuel. Augmenting energy needs with renewable energy systems allows engineer resources to be freed up for use in areas of greater importance. Communication lines are strengthened by reduction in the

number and frequency of convoys hauling fuel, resulting in less vulnerability to direct attack, reduction or elimination of civilian assets hauling waste, and decreased need for or demand upon Host Nation resources in the form of water, fuel, energy, and sanitation support. Improved sanitation conditions results in health promotion of the force by decreasing disease exposure from trash and filth, thereby lowering the potential for disease and non-battle injury incidence.

Most renewable energy systems are procured as COTS systems and are selected following commercial system development that demonstrates their dependability, durability and reliability. Renewable energy systems significantly decrease the chance for petroleum product spills and associated public relation issues, decrease carbon dioxide (CO2) emissions preventing pollution, and are environmentally sound and friendly, thus adhering to the Army Posture Statement and the Army Strategy for the Environment.

Renewable energy systems can offer the Commander improved deployability, enhanced survivability, greater maneuverability, improved use of resources, modularity, durability, reliability, augmentation of existing resources, and allow for better management of energy and Warfighting systems (see Appendix C for example photographs of renewable energy systems). Renewable energy system use in austere environments can work as a force multiplier to enhance the Commander's overall resources in challenging arenas where future conflicts tend to be headed. While it is doubtful that use of renewable energy systems will completely replace using fossil fuels, use of renewable energy systems can enhance the Commander's energy arsenal, helping him to be less dependent on fossil fuels.

Disadvantages of Renewable Energy Systems

Although there are many advantages in using renewable energy systems, there are likewise some disadvantages. Initial investment and system costs for renewable energy systems can be somewhat higher than conventional systems. Renewable energy systems are weather dependent[37] to some extent and can have a decrease in performance with inclement weather, including low wind speed for turbine systems, low or limited sunlight with photovoltaic energy systems, and excessive moisture with biomass generators or waste to energy conversion systems[38]. By themselves, renewable energy systems may not exclusively meet energy demands of military operations. With today's technology, it is highly unlikely that renewable energy systems will totally replace use of conventional fossil fuel powered generator systems.

Commensurate with the limited use of renewable energy systems in CONOPS, there is limited field testing of renewable energy systems and underlying questions about their durability. Manufacturers may have a limited ability to produce renewable energy systems for the military, since meeting military specifications and system specific maintenance needs can ultimately mean increasing delivery time for ordered renewable energy systems. Little if any formal education or training exists for Commanders to increase their knowledge and confidence about renewable energy systems. Feedback from interviews and references indicates Commanders lack clear understanding of and confidence in the effectiveness and benefits of using renewable energy systems, which in turn limits expanding their use. Significant effort will be required to incorporate institutional, doctrinal, and operational changes necessary to fully integrate renewable energy systems into current and future Warfighting mentality.

Cost of Renewable Energy Systems

The cost of using renewable energy systems goes beyond fiscal considerations. While renewable energy systems have great diversity in cost, some ranging significantly less than $100 to systems well over $100,000, most systems will pay for their purchase and continued use in a matter of months or years. Some photovoltaic and wind turbine systems costing a few hundred dollars can pay for themselves in a matter of months, while renewable energy systems costing tens of thousands of dollars can take up to 10-12 years to pay back. Although this may initially appear concerning to some, it is important to remember that while renewable energy systems are paying themselves off, they are also decreasing the amount of fuel and energy required to operate them, giving added benefit at the onset of use. Energy produced by renewable energy systems can either be used directly or stored for later use if the production exceeds demand.

While some renewable energy systems may cost as much as $100,000[39] or more, the cost is more than saved compared to payment for a single Soldier's Group Life Insurance policy, the on-going cost for health care (initial and sustained treatment, rehabilitation, or for disability costs) for soldiers injured by sniper fire or blasts from roadside bombs[40], or the cost to repair or replace equipment damaged during convoys transporting fuel[41]. Obviously, soldier safety becomes a significant issue of concern. If use of renewable energy systems were to only decrease fuel demand by 25%, the cost savings in life, disability, equipment, and decreased operational expenditures would result in immeasurable savings and more than pay for their use.

Yet another example of concern for safety has been shared by the Marine Corps[42]. In over four years, more than 700 Marines have been killed in Iraq, with nearly two-thirds killed in High Mobility Multi-purpose Wheeled Vehicle (HMMWV) by IEDs. The Marine Corps plans to replace the HMMWV with the V-hull shaped MRAP (Mine Resistant Ambush Protected) vehicles that are reported to have a four to five times greater probability of surviving a blast than those in a HMMWV. Marine Brigadier General Brogan identified that the threat to Marines has changed and protective measures need to change accordingly. Emphasis on safety can lead to changing vehicle protection from HMMWV to MRAPs. One may wonder if the same principle applies to use of renewable energy systems. Simply stated, use of renewable energy systems can greatly decrease the need for fossil fuel, which in turn keeps Marines and soldiers out of harms way from hauling fossil fuel and significantly decreases their exposure to enemy threat.

The cost for renewable energy is actually not that expensive compared to the total cost of fuel. Estimates from August to November 2006 identify in-theatre costs for fuel ranges from $5-12 per gallon[43]. However, when adding in the total cost to handle (ports of embarkation and debarkation), ship (transcontinental and/or transatlantic), and transport fuel by tanker trucks in Iraq, the cost jumps dramatically to estimates of up to $100-300 per gallon[44]. On the other hand, renewable energy systems do not require fuel to operate. Wind turbines often produce energy at a cost of only 4-6 cents per kilowatt hour, with productivity dependant on wind speed. Depending on the photovoltaic array and composition, the cost for solar energy is approximately 20-30 cents per kilowatt hour, with peak power production (mid-afternoon) typically matching the time of peak

energy demand. Both of these renewable energy systems are incredibly inexpensive compared to the actual cost for fuel in Iraq.

Operational readiness is augmented through enhanced maneuverability, with a significantly reduced logistic footprint, thereby allowing for greater versatility and increased sustainability. Integration of renewable energy systems into current power generation systems allows for significant reduction of fuel use and associated resources to transport fuel is reduced[45]. Renewable energy systems are easily maintained[46], reliable, durable, and dependable, offering Commanders the ability for increased operational tempo through force allocation from resources (personnel, time, and equipment) saved from transporting fuel to run conventional generators[47]. Force protection and security are significantly improved through limiting the number and volume of convoys currently required to transport fuel[48]. Additionally, operational security improves by reducing, or in some cases eliminating, vulnerabilities of friendly actions to adversary exploitation, by decreasing his intelligence capability (reduction of convoys, fuel use, trash, etc.) and limiting his ability to obtain critical information.

Impediments to Implementation

Given all the above advantages of renewable energy systems it is difficult to understand why these systems are not used more often. The United States Army fields equipment (some of which was developed decades ago and includes energy systems) that often dictate current energy requirements, technology, and supply sources through fuel demands and system efficiencies or inefficiencies. In reality, impediments to Commanders' use of renewable energy systems are vast and varied. This writer believes

there are six key impediments to the Army's increased use of renewable energy systems. They include:

1. Leadership Issues
2. Doctrine/Policy Issues
3. Institutional Perceptions
4. Acquisition Process
5. Renewable Energy Expertise
6. Financial Considerations

Leadership issues exist at various levels of the Army regarding use of renewable energy systems, from lower enlisted soldiers to Senior Leaders. Due to the Army's failure to educate Commanders about renewable energy systems, many Commanders lack the confidence, vision, and insight as to how to effectively employ renewable energy systems and how renewable energy systems can impact the force structure. In addition, most junior soldiers are unaware of the various renewable energy systems currently available that could be employed to both maintain and improve operational effectiveness while decreasing the need for fossil based fuel. There is a definite lack of reported need for renewable energy systems by Senior Leaders, major Combatant Commanders, senior noncommissioned officers, or leaders in line units. An extensive literature review resulted in only one Combatant Commander, MG Zilmer, identifying a need for renewable energy systems. Currently, there appears to be little interest or command emphasis toward implementation of renewable energy systems, and no single person is clearly identified as a "Champion" that could propagate the need for and importance of using renewable energy systems.

There is limited reference in Army doctrine and policy to employ renewable energy systems during CONOPS and what is referred to appear outdated. There is limited information found in Army regulations, policies and procedures, technical manuals, supply and re-supply procedures, operations, or Mission Essential Task List (METL) requirements to use renewable energy systems. This continued use of old or outdated doctrinal belief by Army Leadership regarding traditional energy sources without serious consideration to the benefits of renewable energy systems can significantly limit options for efficient means of generating, converting, and utilizing energy.

Military service schools at all levels lack incorporating or making reference to use of renewable energy systems in their various curriculums. Addressing use of renewable energy systems is absent from the general instruction at Basic Combat Training, Advanced Individual Training, NCO Development Schools, Basic Officer Leaders Course, Captains Career Course, as well as at Officer and NCO advanced education schools. Institutional beliefs and stereotypes can only be changed with infusion of current information on renewable energy systems and their ability to enhance the mission. The current preconceived mindsets, established biases, and cultural issues about the Army's "energy institution" must be overcome. There is not an unlimited source of fossil fuel available for energy wherever and whenever needed. This energy comes at a price; the cost in dollars to purchase fuel, equipment to haul it, and vulnerability of soldiers assigned to convoys bringing fuel to run generators.

The Army acquisition process is a system of checks and balances that ensure items achieve a specific standard before they are fielded. This is a fairly lengthy process

typically taking up to 10 years or longer to complete. The acquisition process addresses design, development, and production of new systems, including modifications to existing systems that require redesign of the system or subsystem. The time from start to fielding of equipment varies greatly, depending on multiple factors, including technology or complexity of the system. Renewable energy systems are tested by manufacturers as part of their development process, yet still require extensive review and analysis through the acquisition process. This, in turn, significantly delays renewable energy systems availability for soldier use. The Stryker vehicle is an excellent example of how a system can be moved quickly through a lengthy acquisition process. The time from product commencement to soldier availability of this system was about a fraction of the time it normally takes for equipment to be fielded. Expediting the acquisition process without compromising the efficiency of the renewable energy systems can be an effective solution to assigning a federal stock number and TOE line item number to renewable energy systems, thereby expediting fielding this important equipment.

Renewable energy expertise is limited in the Army in terms of operation, maintenance, and repair of renewable energy systems. With the continued limited use of renewable energy systems by the Army, it will be extremely difficult, if not impossible, for the Army to develop experts in these areas. There is skepticism by some that the industry is ready and able to produce sufficient quantity and quality of deployable renewable energy systems at a reasonable price, and in a timely manner that meet military specifications. Having these requirements clearly identified in military contracts will help overcome this skepticism. Obtaining standardized designs and fabrications for CONOPS is crucial to renewable energy systems use and will most likely not occur

without a definite requirement and demand. With an increased use of renewable energy systems by the Army, renewable energy systems expertise is sure to follow.

Lastly, renewable energy systems can require a fairly significant initial financial investment. While renewable energy systems typically pay for themselves in a few years, payback varies according to the configuration of the individual system, where and when the system is deployed, the frequency and duration of system use, and the efficiency of the particular renewable energy systems. It is difficult to understand how one can maintain the position of renewable energy systems being costly even when compared to the cost of fuel used by conventional generators alone. Even with renewable energy systems being more expensive to by a typical fuel generator, the operational cost payoff in the long run makes the investment worth while.

Cost savings can be illustrated by Wal-Mart's modifications to the second largest commercial trucking fleet in America. Installing auxiliary power units on their trucks will enable drivers to keep their cabs warm or cool during breaks from the road without the use of the primary diesel engine. Wal-Mart estimates it could save up to $26 million a year in fuel costs alone. Wal-Mart's new sustainability plan seeks to increase the efficiency of its vehicle fleet by 50% over the next ten years and reduce energy demands in their facilities by 30%. Their investment now greatly pays for itself in the future.

At a cost of hundreds to even hundreds of thousands of dollars for various renewable energy systems, this investment is greatly cheaper than the millions of dollars currently spent on fuel to run traditional generators for energy. The legislative process also places little importance on use of renewable energy systems as funding for their purchase and use is continually cut. If the Army were to become a major purchaser of

renewable energy systems, the cost for renewable energy systems would certainly decrease due to the purchasing power of the Army. As the demand for renewable energy systems increases, the cost for these systems will in turn decrease. Increased demand for renewable energy systems by the Army would significantly leverage manufacturers to meet military demands and specifications, influence improvements in technology, increase availability of renewable energy systems, promote greater system efficiency, and thereby, increase the Army's use of renewable energy systems.

Overcoming Impediments

Changing the focus of renewable energy systems from an "environmental" reference to that of enhanced Warfight capacity is important. Use of renewable energy systems is a value added resource to Commanders. Renewable energy systems enhance combat readiness and effectiveness through decreased logistical support, becoming a force multiplier and augmenting Warfighting capability. Use of renewable energy systems builds force protection posture for the Commander and can save soldier lives by decreasing or removing the need for moving fossil fuel, thus avoiding soldier exposure to IED attack in convoys. Renewable energy systems are a value-added resource for Commanders and are environmentally friendly by avoiding pollution. Renewable energy systems can also be a future recruiting tool. As renewable energy systems are implemented, renewable energy systems experts and associated soldier technical skills will be required.

The United States Army is in need of both doctrinal changes and an overhaul of the soldier education system at all levels, incorporating use of renewable energy systems

in the Warfighter mentality. A need for organizational change, cultural change, and change in institutional beliefs is overdue. The military educational institution must take an aggressive role with the responsibility for changing doctrine, developing and implementing training, and to facilitate greater use of renewable energy systems. Increased use of renewable energy systems by Commanders will bring about a need for and in turn build skill sets of soldiers. However, this will not be an easy task. The current military culture is an environment that will require a massive educational effort to fully understand the associated benefits of renewable energy systems. Furthermore, the military education system at all levels will need to infuse sufficient experts in renewable energy systems to enrich the military culture on using renewable energy systems to enhance the Warfighter. One can only wonder what impact inclusion of renewable energy systems with the Future Combat Systems would have in bolstering the Warfighter's arsenal.

Use of renewable energy systems should be part of the Unit METL. Consideration must be given to finding ways to deploy with renewable energy systems, instead of Commanders having to wait for months or years to get renewable energy systems after they are deployed. Commanders, and the Army as a whole, will need to make a paradigm shift regarding their perception of renewable energy systems. Without this change in perception, Commanders will continue to maintain unnecessary restrictions regarding their ability to use all resources and technologies available to them when engaged in CONOPS. Renewable energy systems need to have assigned federal stock numbers and TOE line numbers so they can be ordered through the supply system and thus more fully incorporated, available, and used in the force structure.

Joint Operations requirements for using renewable energy systems are critical. Leadership Training on renewable energy systems and technical training programs for sustainable practices must be developed and implemented. Trained personnel - Soldiers and Civilians – are required to quickly and effectively bring renewable energy systems into the military at an expanded rate. Commanders must place increased emphasis on using renewable energy systems and for focusing the mission on sustainable operations. This in turn will lead to having renewable energy systems personnel with dedicated specialties and skill sets to further enhance the Commander's Warfighting capabilities. Reutilization of Command resources is greatly increased with little need for or dependency on Host Nation resources. Decrease in cost with use of renewable energy systems allows Commanders to utilize budgeted monies for operational needs rather than adjusting the budget due to the budgetary drain of raising fuel costs.

Renewable energy systems help the Commander to work towards a "Zero Footprint" force with the ability to be sustainable over the long haul. By using renewable energy systems, Commanders become more operationally independent when not having to rely as heavily on traditional fossil fuels for energy needs. Use of renewable energy systems give the Commander heightened survivability since his units are more maneuverable, agility and flexibility enhanced, and operational security is augmented.

Recommendations

Leadership

Use of Renewable Energy Systems in CONOPS is a relatively new concept for the Army and DoD, but not the need for energy. Education and training on renewable

energy systems at all levels will be crucial to overcome preconceived ideas about what renewable energy systems can and cannot do. The current mindset and culture regarding the use of renewable energy, or the lack thereof, must change. Continued research and development on renewable energy systems is a necessity and must be a priority for Army sustainability and be paramount for the Warfighter. Renewable energy systems need integration at the strategic and operational levels, as well as from an informational perspective.

Establishing and implementing a Tiger Team to address and influence HQDA policy, gaps, and funding issues with possible implementation of a Renewable Energy Systems Command may be beneficial. With greater understanding of renewable energy systems, Commanders and Leaders at all levels will be able to incorporate renewable energy systems into operational planning at the earliest stages in order to enhance mission execution. Key Leaders in the Army as well as in the Joint Community have a responsibility to make appropriate changes in doctrine, organization, leadership, training and education, personnel systems, and unit equipment to address various solutions regarding the importance of using renewable energy systems.

Doctrine/Policy

New concept plans must be developed with emphasis on changing current military doctrine, to include use of renewable energy systems. Research and development will drive strategies for implementation of renewable energy systems and associated working groups on how to better employ them. Renewable energy systems will in turn require a need for a federal stock number and TOE authorization as these systems are incorporated into the military supply system.

Institutional Perception

Skill sets of the soldier will need to include use of renewable energy systems at the earliest opportunity. Basic Combat Training, Advanced Individual Training, Warrior Leadership Course, Basic Officer Leaders Course, Captains Career Course, Senior Officer and Enlisted Service Schools are examples of opportunities for soldier education on renewable energy systems. In addition Common Task Training, ARTEP Exercises, Field Training Exercise, and Joint Training events must include planning for and use of renewable energy systems. With an atypical, asymmetrical battlespace, it is crucial for Leaders to be future thinkers and understand the importance of taking every opportunity to use renewable energy systems to their fullest extent.

If the Army fights as it trains, then it must train with renewable energy systems to ensure proper application of these systems, soldier knowledge and competence of their use, and on-going soldier proficiency. Including renewable energy systems as part of the Unit's METL further emphasizes the Commander's importance of their role to the soldier and the mission. Clear lines of responsibility and requirements for renewable energy systems use must be clearly articulated up and down the Chain of Command to achieve the greatest success in incorporating renewable energy systems into CONOPS missions.

Acquisition Process

Improvement could occur within the Army acquisition process, bringing renewable energy systems to the Warfighter faster. As most of the research and development occurs by the manufacturer, an expeditious process should be in place to acknowledge the scientific work already completed. It may be advantageous to field test renewable energy systems in CONOP settings similar to the process done with the Striker

vehicles. This could reduce or eliminate any additional research and development needed by the Army, thereby speeding the acquisition process to more quickly move renewable energy systems to the field.

Expertise

There is a need to change the perception of renewable energy systems from an "environmental benefit" to enhancing Warfight capacity. Even though renewable energy systems avoid pollution and are environmentally friendly, their primary function is to provide the Commanders with a viable, dependable energy source with a significant reduction in the need for fossil fuel and the associated fossil fuel burden (cost, transportation, storage, soldier exposure to IED attack during convoys, etc.). Renewable energy systems enhance combat readiness and effectiveness through decreased logistical support, becoming a force multiplier augmenting the Commander's Warfighting capability. Furthermore, using renewable energy systems enhance force protection posture for Commanders and keep soldiers out of harms way. Renewable energy systems can also be a future recruiting. As renewable energy systems are implemented the need for renewable energy systems specialists grows.

Funding

Appropriate funding for the purchase of renewable energy systems, and further research and development is crucial. Allocating $23 million for renewable energy systems and having this cut to $3 million is unacceptable. If the U.S. Army is to make a serious impact on decreasing its use of and dependence on fossil fuel, it must budget for and procure renewable energy systems as aggressively as it does other soldier systems. Without this commitment little will change. Soldiers will continue to be in harms way

with convoy duty, millions of gallons of fossil fuel will be used to power generators, and billions of dollars will be spent on less efficient energy systems.

Sustainability

Use of renewable energy systems in initial planning for Base Camps Operation will be a vital component of CONOPS as Commanders can expect lines of supply to be strained at times and Host Nation Support to be limited. Renewable energy systems can greatly impact sustainability needs, including heat and electricity for tents, hot water for showers and mess needs, and decreased environmental impact through stewardship and responsibility. Waste becomes an energy source rather than a logistical burden, habitat for disease vectors, or an intelligence opportunity for the enemy. Burning waste can result in a steady source of CONOP energy rather than a command burden of waste disposal. Use of renewable energy systems offers solutions to Commanders for decreasing fuel needs while enhancing the capability of their unit.

Conclusion

Having dependable, secure energy is a national security issue. It is clear that the United States Army will always require energy as a key resource to accomplish its mission. As fluctuating oil prices grow ever higher, world oil supply continues to diminish, and the demand for energy increases at an ever increasing rate, energy requirements will undoubtedly influence all aspects of military operations, from lethal engagements to Contingency Operations. Renewable energy systems are not a “one size fits all” option or intend to be the ultimate replacement of current energy sources. Rather, renewable energy systems augment current energy systems and are viable,

efficient energy systems that can provide the Warfighter with abundant energy improving his overall capability.

Use of renewable energy systems will enhance mobility, maneuverability, survivability, sustainability, and stealth - yet decrease detection, storage, transportation needs, and waste. Lighter systems result in less weight and fewer assets to transport energy producing systems. Communication lines are more secure and the logistical footprint is significantly decreased due a lower fuel demand. Use of renewable energy systems can increase energy efficiency, improve energy security, increase soldier safety, and reduce dependence on fossil fuels. Commanders can focus their attention on mission priorities, rather than focus on transportation of fuel or exposing their soldiers to hazards from IED attacks. Renewable energy systems have the unique ability to offer Commanders important characteristics that fossil fuels lack and at a price fossil fuels can no longer provide.

Establishing and implementing an integrated, cross functional approach to provide recommendations of the right training, education, and direction in the use of renewable energy systems is paramount to the Army. Changes in current and future doctrine, along with policy emphasis on employment of renewable energy systems must occur. Use of renewable energy systems not only increases soldier safety through reduction of logistics footprint, it also serves to save equipment, money, helps preserve natural resources, demonstrates environment stewardship, and greatly reduces the Army's reliance on fossil fuels. The old proverb is true; "If we continue to do what we have always done, we will continue to get what we have always gotten". We cannot depend on foreign oil when that dependence is no longer sustainable.

Appendix A

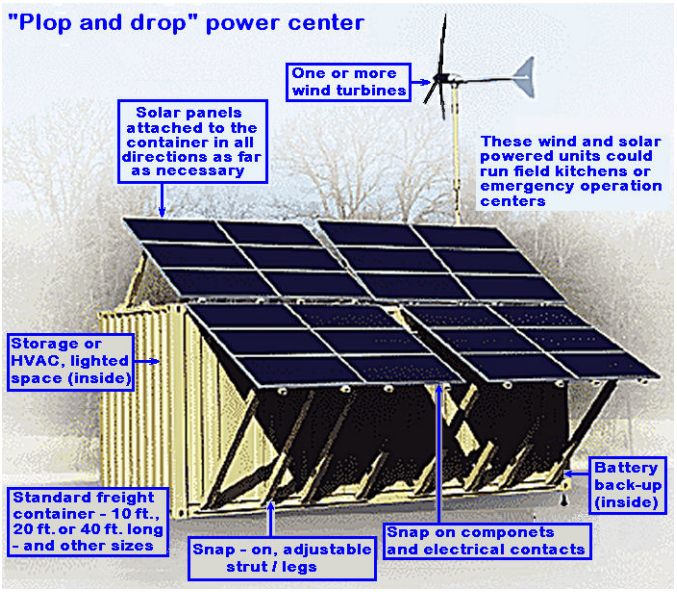


Figure 1
SkyBuilt© Power's Renewable Energy System; Solar, Wind, and Micro-Hydro.

Appendix B

Figure 2
Biomass Generator

Figure 3
Biomass feedstock

Figure 4
Biomass feeder

Appendix C

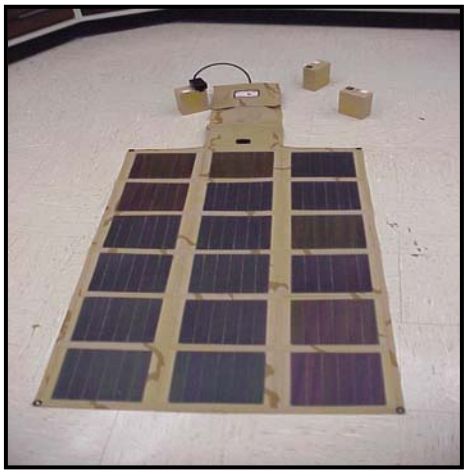


Figure 5
Thin Film Solar
Battery Charging Unit

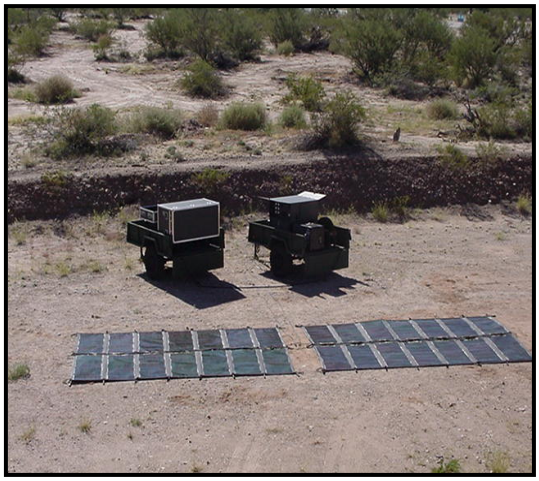


Figure 6
Thin Film Solar Panels
with Field Generators

Figure 7
Solar Panel Canopy

Figure 8
Field Trailer with Solar
and Wind Turbine Systems

Endnotes

[1] State Of The Union Address By The President, United States Capitol, Washington, D.C., 31 January 2006. President Bush acknowledged that the United States is addicted to oil and a need for alternative energy sources. Breakthroughs and new technologies will help the United States replace more that 75 percent of its oil imported from the Middle East by the year 2025.

[2] "Al Qaeda Faction Urges Oil Attacks." Los Angles Times, 15 February 2007. Available from http://ebird.afis.mil/ebfiles/e20070215489580.html. Accessed 15 February 2007. The Associated Press reported "Militants are told to strike worldwide" to disrupt the oil supply to the United States.. A terrorist group in Saudi Arabia with ties to Al Qaeda urged Muslim militants to attack oil facilities around the world including Venezuela, Canada, and Mexico. The intent is to stop or seriously impede the flow of oil to the United States believing this action would seriously impact American occupation of Iraq and Afghanistan. Al Qaeda attacked oil installations in Yemen and Saudi Arabia in 2006 after a call from Bin Laden for militants to stop the flow of oil to the West. The group was also responsible for an attack on a French oil tanker in the Gulf of Aden in 2002 that killed one person.

[3] "OPEC to cut 500,000 bpd in Feb.: Cartel postpones further reduction until after passing of peak winter demand." *Money.Com*, 14 December 2006. Available from http://money.com/2006/12/14/news/international/opec.reut/index.htm?postversion=2006121406. Accessed 14 December 2006. "The group that pumps over a third of the world's oil has already curbed output this year by 1.2 million bpd [barrels per day] to 26.3 million in October to halt a 10 week, 25 percent price slump." This clearly demonstrates OPEC has significant influence and impact on US oil prices. "Oil has fallen from a mid-July peak of $78.40 but is still three times the price at the start of 2002 as Asian demand kicked in. Refining constraints and worries over supply from Iraq, Nigeria, Iran, and Russia helped fuel the rally."

[4] Ixer, Steve. "US Government Reviews Oil Supply Relationship With Venezuela." Available from http://www.vcrisis.com/index.php?content=letters/200501130405.

[5] Ibid.

[6] Bernhard, Kent Jr. "Pump prices jump across U.S. after Katrina." *American City Business Journals*, 1 September 2005. After Hurricane Katrina, gasoline prices ranged from $2.99 per gallon in Orlando, Florida to $3.78 per gallon in Stockbridge, Georgia. September 2005 unleaded gasoline futures were trading at a record high at $2.68 per gallon.

[7] Bamberger, Robert L. and Kumins, Lawrence. Oil and Gas: Supply Issues After Katrina, Congressional Research Services, The Library of Congress, Updated 6 September 2005. The Outer Continental Shelf in the Gulf Of Mexico is the source for 25% of U.S. crude oil production. Approximately 1.3 million barrels of refining capacity daily remained shutdown immediately after Hurricane Katrina. Due to the devastation from Hurricane Katrina, on 2 September 2005, President Bush authorized the use of 9 million barrels of crude oil daily from the Strategic Petroleum Reserve.

[8] Farivar Masood. "Military Seeks Oil Savings; Rising Demand, Supply Risks Spur Conservation Move." *The Wall Street Journal*, 9 January 2007. Available from http://www.ebird.afis.mil/ebfiles/e20070109479276.html. Accessed 9 January 2007.

[9] Clayton, Mark. "In the Iraqi War Zone, US Army calls for 'Green' Power." *The Christian Science Monitor*, 7 September 2006. Available from http://www.csmonitor.com/2006/0907/p01s04-usmi.htm. Accessed 7 September 2006.

[10] Energy Efficiency and Renewable Energy Legislation in the 109th Congress. Available from http://www.theorator.com/bills109/hr4897.html.

[11] *Crude Oil and Total Petroleum Imports Top 15 Countries*. Energy Information Administration. Available from http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/company_level_imports.

[12] *Crude Oil and Total Petroleum Imports Top 15 Countries.* Energy Information Administration, 15 November 2006. Available from http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/company_level. Accessed 21 November 2006. Crude Oil Imports (Top 15 Countries) (Thousand Barrels per day) for the United States. This article reflects several categories including Jan-Sep 2005, Sep 2005, Aug 2006, Sep 2006, and YTD 2006. The top five exporting countries accounted for 64 percent of the United States' crude oil imports in Sep 2006 while the top 10 countries accounted for approximately 85 percent of the crude oil imports for the United States.

[13] "U.S. Troops On Their Way To Help Kenya Flood Victims." *Stars and Strips*, 8 December 2006. Available from http://ebird.afis.mil/ebfiles/e2061208472198.html. Accessed 8 December 2006. Due to flooding near Ifo and Dagahley, Kenya, members of the American-led Combined Joint Task Force-Horn of Africa have been sent to provide humanitarian aid to some 100,000 refugees. The military is exploring the best way to transport relief supplies into the affected regions. Approximately 50 U.S. service members and one C-130 Hercules aircraft will assist to perform air-dropping supplies in the region. "It is a small number, but I assure it provides a huge footprint in the area and you can definitely tell an area that we have touched." "U.S. efforts in the region include training foreign militaries and civil-military projects and construction project to combat extremism."

Hoge, Warren. "U.S. Proposing Regional Force To Monitor Somalia Violence." *New York Times*, 2 December 2006. Available from http://ebird.afis.mil/ebfiles/e20061202471028.html. Accessed 4 December 2006. The United States presented a draft resolution on Somalia urging presence of a peacekeeping force to monitor tensions in that country. "The 8,000-member force would come from seven East African nations" excluding the nations currently experiencing conflict in the area. "Somalia has not had an effective government since 1991, when warlords overthrew the president and then turned on each other." The American ambassador John Bolton stated "You know, people criticize us when we take action on the ground, that our taking action makes the situation worse…O.K., so what is the answer not to take action?"

[14] State Of The Union Address By The President, United States Capitol, Washington, D.C., 31 January 2006.

[15] Stout, David. "U.S. To Create A Single Command For Military Operations In Africa." *New York Times*, 7 February 2007.

[16] Royce, Ed. "Pentagon Imperative: A Spotlight On Africa." Christian Science Monitor, 14 November 2006. Available from Http://ebird.afis.mil/ebfiles/e20061114467889.html.

Bender, Bryan. "Pentagon Plans New Command To Cover Africa." *Boston Globe*, 21 December 2006. Available from http://ebird.afis.mil/ebfiles/e20061221475498.html. Accessed 21 December 2006.

[17] DeYoung, Karen. "U.S. Sees Growing Threats in Somalia: Al-Qaeda's Influence, Possible War With Ethiopia Are Concerns." *Washington Post*, 18 December 2006. Available from http://ebird.afis.mil/ebfiles/e20061218474663.html. Accessed 18 December 2006. "Meanwhile, a major war – promoted and greeted approvingly by Osama bin ZLaden- looms between Somalia and Ethiopia, threatening a regional conflagration likely to draw more foreign extremists into the Horn of Africa. Among administration officials, Congress, U.S. allies and other interested and fearful parties, there is a rising sense that Somalia is spinning rapidly out of control. But even as events there have focused Washington's attention, they have led to a wave of finger-pointing and a feeling that there are few good ideas and little time for turning the situation around."

[18] Lovins, Armory B. and Lovins, L. Hunter. *Brittle Power: Energy Strategy for National Security*. Brick House Publishing, Andover, Massachusetts, 1982.

[19] For the purpose of this paper, the term "Commander" will equate as follows: **Commanders**—Those individuals that have a direct impact on decisions regarding military operations, policy, and doctrine that includes but is not limited to senior leaders, commissioned officers, noncommissioned officers, junior soldiers, and policy makers and planners where their decision and /or action results in planning for and equipping the Warfighter.

[20] For the purpose of this paper, the term "CONOPS" will equate as follows: **CONOPS**—Large-scale peace operations (or elements thereof) conducted by a combination of military forces and nonmilitary organizations that combine one or more of the elements of peace operations which include one or more elements of other types of operations such as foreign humanitarian assistance, nation assistance, support to insurgency, or support to counterinsurgency. (Taken from Joint Publication 3-57, Joint Doctrine for Civil-Military Operations, 8 February 2001.)

[21] Clayton, Mark. "In the Iraq War Zone, US Army calls for 'Green' Power." *The Christian Science Monitor*, 7 September 2006, pg 1. Available from http://www.csmonitor.com/2006/0907/p01s04-usmi.htm. Accessed 7 September 2006.

[22] Ibid.

Herro, Alana. "Without Renewable Power, U.S. Could Fail In Iraq." WorldChanging.com, 5 October 2006. Available from http://www.worldchanging.com/archives/005012.html. Accessed 5 October 2006.

[23] Bender, Bryan. "Roadside Bombs Kill Troops At Highest Rate Of Iraq War." Boston Globe, 17 December 2006. Available from http://ebird.afis.mil/ebfiles/e20061217474565.html. Access 18 December 2006. "US troops in Iraq are dying in roadside bombings at a higher rate than any period since the war began –some in follow-up attacks in the same location – but commanders still have no effective means to monitor the deadliest routes for patrols, according to Pentagon officials and documents." Although it is reported the vast majority of IEDs are disarmed or rendered harmless, some officials report a dramatic increase in the number of roadside bombings over several months.

[24] U.S. Department of the Army. *2006 Posture Statement*. Washington, D.C.: U.S. Department of the Army, 10 February 2006.

[25] Office of the Assistant Secretary of Defense. Defense Energy Program Policy Memorandum (DEPPM) 92-1, 14 January 1992. Accessed 8 November 2006. This document demonstrated the importance of energy security and Commander's measures to address vulnerabilities in the disruption to their energy supply and the need for risk assessment of potential disruptions.

[26] Ibid.

[27] "Tri-Service Renewable Energy Committee (TREC) Project Listing." Army Energy Listing [September 2006]. Available from http://acq.osd.mil/ie/irm/Energy/renew_energy/Army.htm. Accessed 5 September 2006. This article addresses Army use of Photovoltaics, Wind, Solar Hot Water, Swimming Pool Heating, Transpired Solar Collector, Geothermal Heat Pumps, and other Renewable Energy Technologies on military installations including the size-KW of the unit, number of units, and when the unit was installed.

[28] Siegel, Steven. Vice President Energy and Security Group. Interview by author, 27 September 2006, Reston, Virginia.

[29] Samuelson, Lynne. *Advanced Solar Energy Solutions for the Warfighter Workshop*. Briefing slides and scripted commentary. U.S. Army Natick Soldier Center (NSC), Massachusetts, 17 November 2006.

[30] Feldman, Scott and Cygan, Peter. "Battery Use by Today's Soldiers." 8 October 2004. Information briefing to this author by Lynn Samuelson 7 November 2006.

[31] Keith, Miriam. *BEAR Base Solar Power System Advanced Solar Energy Solutions for the Warfighter*. Briefing slides and scripted commentary. Air Force Research Laboratory (AFRL) Airbase Technologies Division Deployed Systems Branch AFRL/MLQD, Tyndall Air Force Base, Florida, 1 November 2006.

[32] Ibid

[33] *US Army's renewable power*, 19 September 2006. Avialable from http://www.off-grid.net.forum/viewtopic.php? Accessed 21 November 2006.

[34] Muchow, Dave. President and CEO of Sky Built Power. Telephone interview by author, 8 September 2006.

[35] Bishnoi, Rati. "Renewable Energy Systems Wanted in Iraq." *Military.Com*, 11 August 2006. Available from http://www.military.com/features/0,15240/109512,00.html. Dave Muchow, owner and CEO of Sky Built Power reported that his system "can cut cost by 75% while improving reliability, saving manpower and spare parts, reducing or eliminating fuel costs, handling, and logistics, and providing a low heat signature."

[36] Kinnevan, Kurt. Directorate of United States Army Environmental Integration, Fort Leonard Wood, Missouri. Telephone interview 26 September 2006, and interview by author 25 November 2006, Carlisle Barrack, Pennsylvania.

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[37] Tester, J. W. Professor Massachusetts Institute of Technology. Interview by author, 17 November 2006, MIT, Boston, Massachusetts.

[38] Knowlton, Leigh. *Mobile Integrated Sustainable Energy Recover (MISER) Waste to Energy Conversion.* Briefing slides and scripted commentary. U.S. Army Natick Soldier Center (NSC), Equipment & Energy Technology Team Combat Feeding Directorate, Natick, Massachusetts, 17 November 2006.

[39] Bishnoi, Rati. "Renewable Energy Systems Wanted in Iraq." *Military.Com*, 11 August 2006. Available from http://www.military.com/features/0,15240/109512,00.html. "The up-front capital costs…[of a Sky Built Mobil Power System] (MPS) (around $100,000 depending on the configuration), but after only [three to five] years these costs are recovered,"

[40] Gordon, Michael R., Mark Mazzetti, and Thom Shanker. "Insurgent Bombs Directed at G.I.'s Increase in Iraq." *New York Times*, 17 August 2006.

[41] Hall, Kevin G. and Montgomery, Dave. "War Cost Has Hidden Tolls." *Miami Herald*, 6 December 2006. Available from http://ebird.afis.mil/ebfiles/e20061206471866.html. Accessed 6 December 2006. "Official Iraq War costs mount, but they don't tell the whole story: There also are social cost, future healthcare costs, and readiness costs." Over 2,900 soldiers have died in Iraq and Afghanistan, 73,000 soldiers returning home have been diagnosed with post-traumatic stress disorder, drug abuse and depression, over 19,000 soldiers have been wounded or injured (most of them serve), and thousands of

military vehicles stateside are waiting repairs due to budgetary limitations. Red River Army Depot in Texas is reported to have 6,200 Humvees, Bradley Fighting Vehicles, trucks and ambulances awaiting repairs due to insufficient funding. Anniston Army Depot is reported to have 1,885 tanks and other armored vehicles waiting repairs. Anniston's numbers have increased from previous years.

[42] Wood, David. "Marines To Replace Humvees In Iraq." *Baltimore Sun*, 15 February 2007. Available from http://ebird.afis.mil/ebfiles/e20070215489611.html. Accessed 16 February 2007.

[43] Siegel, Steven. *Sustain the Mission Project (SMP)*. Information brief to Mr. Pybus, Deputy Assistant Secretary of the Army, Integrated Logistics Support. Briefing slides and scripted commentary. Army Environmental Policy Institute (AEPI), 17 August 2006. Incorporating the cost of shipping fuel (from purchase site to Port of Embarkation, shipping vessel, Port of Debarkation, associated handling fees and intra-theatre transportation and handling costs, the real cost for fuel ranges from just under $5 a gallon to over $12 a gallon.

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[44] Donnelly, John. "Military wants a more fuel-efficient Humvee: Pentagon makes an energy push." *Boston Globe*, 2 October 2006. Available from http://www.boston.com/news/nation/washington/articles/2006/10/02/military_wants Accessed 3 October 2006. Donnelly reports "estimated that getting gas to a tank in Iraq could cost ass much as $100 a gallon, considering the cost of supply lines, tanker vehicles, and protection of the tankers."

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[45] Beebe, Shannon D. Senior Africa Analyst, HQDA. Interview by author, 28 November 2006, Arlington, Virginia.

[46] Jones, Hugh. Sky-Built Power Senior Consultant. Interview by author, 11 October 2006, Arlington, Virginia.

[47] Kinnevan, Kurt. Directorate of United States Army Environmental Integration, Fort Leonard Wood, Missouri. Telephone interview by author, 26 September 2006 and personal interview 25 November 2006, Carlisle Barracks, Pennsylvania.

[48] Bishnoi, Rati. "Renewable Energy Systems Wanted in Iraq." *Military.Com*, 11 August 2006. Available from http://www.military.com/features/0,15240/109512,00.html. Accessed 11 August 2006.

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